The Roles of the U.S. National Academies in Influencing Federal S&T Initiatives

A Report to NEDO

George R. Heaton, Jr.
Christopher T. Hill
Patrick H. Windham

December 2014

Technology Policy International
www.technopoli.net
An International Consultancy with Representatives in Boston, Washington, and Knoxville

PREFACE

The study underlying this report was commissioned by the Washington, D.C., office of Japan's New Energy and Industrial Technology Development Organization (NEDO).

The report's authors, working together as the firm of Technology Policy International (TPI), have undertaken the study as independent consultants, although it should be noted that each has other professional affiliations and activities (see "About the Authors"). The opinions expressed in this report do not necessarily reflect the views of NEDO or the institutions with which the authors are affiliated.

George R. Heaton, Jr.**
Boston, MA
GRHeaton@aol.com

Christopher T. Hill
Knoxville, TN
Chrishll@erols.com

Patrick Windham
Arlington, VA
PatWindham@aol.com

** Project Manager and Managing Principal, Technology Policy International

ABOUT THE AUTHORS

George R. Heaton, Jr. is a member of the faculty at the Worcester Polytechnic Institute in Massachusetts and an independent consultant in science and technology policy, environmental policy and law. Trained as a lawyer, Mr. Heaton has been on the faculty of the Massachusetts Institute of Technology, and has worked widely for public and private technical and policy institutions in the U.S. and abroad. Maintaining extensive professional and personal relations in Japan, Mr. Heaton was a Visiting Professor at Saitama University in 1986-87 and the First Foreign Scholar of the Ministry of Health and Welfare in 1989-90.

Christopher T. Hill is Professor Emeritus of Public Policy and former Vice Provost for Research at George Mason University in Fairfax, Virginia. He is currently a Senior Fellow at SRI International. After earning three degrees in chemical engineering and practicing in that field at Uniroyal Corporation and Washington University in St. Louis, he has devoted the past four decades to practice, research and teaching in science and technology policy, including service at MIT, the Office of Technology Assessment, the Congressional Research Service, the National Academy of Engineering and the RAND Critical Technologies Institute.

Patrick H. Windham is a consultant and university lecturer on science and technology policy issues. From 1999 to 2012 was a Lecturer in the Public Policy Program at Stanford University. From 1984 until 1997 he served as a Senior Professional Staff Member for the Subcommittee on Science, Technology, and Space of the Committee on Commerce, Science, and Transportation, United States Senate. He helped Senators oversee and draft legislation for several major civilian science and technology agencies and focused particularly on issues of science, technology, and U.S. industrial competitiveness. Mr. Windham received an A.B. from Stanford University and a Master of Public Policy degree from the University of California at Berkeley. He currently lives in Arlington, Virginia.

The Roles of the U.S. National Academies in Influencing Federal S&T Initiatives

The Questions from NEDO and the TPI Responses

NEDO has asked TPI, "...in what way and to what extent do the National Academies interact with, and affect, decisions of the Federal government in its course of formulating/updating S&T related initiatives?" We address these questions by examining four classes of studies carried out by the National Academies that address S&T initiatives and priorities directly.[1] We also discuss activities of the National Academies, other than conducting studies, that influence Federal S&T activities and priorities. The paper concludes that, while it can be difficult to measure the contributions of the National Academies to federal policy making, the fact that decision makers return repeatedly to the Academies for advice is a good indication that they value it highly.

The report begins with some general background information on the National Academies to provide a proper context for understanding their work.

Part I—The U.S. National Academies

History and Organization of the National Academies

The U.S. National Academies include the National Academy of Sciences (NAS), the National Academy of Engineering (NAE), the Institute of Medicine (IOM), and the National Research Council (NRC). The Academies are chartered both to recognize outstanding individual achievements in the sciences, engineering and medicine, and to provide advice to the Federal government and the nation on matters involving expert knowledge in their fields of competence,

[1] The Academies annually conduct hundreds of studies and other activities related to understanding and analyzing scientific and technical topics, including those intended to help policy makers make decisions. This report focused on the important subset of Academy contributions to formulating and improving science and technology-related initiatives. For an overview of the Academies, their recent reports, and expenditures, see: 2013 Report to Congress, National Academy of Sciences, National Academy of Engineering, Institute of Medicine, National Research Council, undated. Can be downloaded at: http://national-academies.org/annualreport/

broadly defined. Throughout this report, we refer to them collectively as the Academies or the Academy complex.[2]

The NAS was established and given a formal charter by the United States Congress in 1863 to give advice on scientific matters that had arisen in connection with the U.S. Civil War. For many years, engineers were admitted as members of the NAS. However, in 1964, the NAE was established to focus specifically on engineering and technology subjects, functioning under the NAS congressional charter. The IOM was founded six years later, in 1970, also under the original NAS charter.

In order to engage people with expertise not necessarily represented among the Academy members, as well as to expand the number of people who could participate in Academy studies, the NAS established in 1916 the National Research Council (NRC[3]), which is also recognized in the NAS charter as amended. As the organizations have evolved, the NRC is typically referred to as the operating arm of the National Academies. The officers of the NRC are the officers of the Academies, but the NRC has no members as such. However, the NRC has a permanent staff of professionals and supporting personnel totaling around one thousand people. The staff orchestrates the work of the participants in NRC studies, who may total ten thousand or more people each year.

The senior officers and the staff of the Academies, including the NRC staff, receive salaried compensation from the Academies for their services. Neither the general members of the Academies nor participants in NRC or other Academy studies are compensated. No one at the Academy receives compensation directly from the Federal government for their work, compensated or volunteered, at the Academy. A key difference between the U.S. National Academies and national academies of a number of other countries is that the U.S. National Academies do not in general distribute research and development funds or other financial

---

[2] See: www.nas.edu. Many U.S. organizations refer to themselves as the "National Academy" of one thing or another, such as the National Academy of Public Administration, the National Academy of Education, the National Academy of Inventors, and the National Academy of Elder Law Attorneys. No other organization with the name "National Academy of XXXX" is part of the Academy complex that is the subject of this report.

[3] The NRC (National Research Council) is, of course, different from the U.S. Nuclear Regulatory Commission (NRC) which uses the same acronym.

supports to their members, nor do they maintain or operate laboratories or other research facilities. To be elected a member of a U.S. National Academy is strictly an honorary position; it carries no commitment of funds to each member.

Each Academy elects its own members, with new members elected annually by secret ballot of the existing members. The Federal government has no say in who is elected. Each Academy also elects a number of foreign associates who are distinguished individuals from other countries. Each Academy has on the order of 1,500 members. Since the United States has several million scientists and engineers, it should be apparent that to be elected to membership is a rare honor that is extended only to the most outstanding individuals.[4]

The Academy Study Process

The Academies, largely through the NRC, are engaged in several hundred studies each year. Most, although not all, of the studies are carried out in response to requests from Federal government agencies. In turn, most of the Academy studies for Federal agencies are requested by the agencies on their own initiative. In a few cases, Congress may direct an agency to request a study by the Academies by inserting a clause to that effect in an agency's authorization or appropriations statute or in some other statute affecting the agency. The Academies also have the authority to initiate studies independently, but they have only a limited amount of resources to conduct such studies.

When a request for a study is received, or when one is initiated by one or more of the Academies, after due consideration by the Academy leadership, a committee of the NRC is formed to do the study and NRC staff are assigned to support the committee's work.[5] The Governing Board of the NRC approves a study plan and committee membership, along with a study budget. Generally, requested studies are executed under a contract between the Academies and the requesting agency, which includes provisions under which the agency will pay for most

[4] The election process is not perfect, of course. Some persons who have made outstanding scientific, technical or medical contributions are overlooked in the nomination and member election processes. Less frequently, someone is elected who perhaps is not entirely deserving of the honor in the opinion of some observers.

[5] For simplicity, we discuss here studies that are assigned to the NRC, which includes the vast majority of Academy studies. The NAS, NAE and IOM occasionally conduct studies outside the NRC framework. Such studies are managed somewhat differently.

or all of the expenses of the study, including NRC staff time, project travel, any consultant fees that might be incurred, committee meeting expenses, publication expenses, and so on. The formal budget for a typical study might be on the order of one to three hundred thousand dollars; longer and more complex studies might cost a million dollars or more.[6] A study may take from a few months to several years to complete, depending on its scope and complexity.

Depending on the scope of the study, a committee typically has ten to twenty members, each of whom is selected because of his or her expertise in the area of the study.[7] For studies of relatively narrow scope that usually address narrow and highly technical questions, the disciplinary and occupational backgrounds of the committee members may be similarly narrow. For more far reaching and complex studies, such as those motivated by high-profile public policy concerns, committee membership may be highly multidisciplinary and be carefully selected to ensure participation by persons from academia, industry, non-profit organizations, competing producers of commercial technologies, supplier and consumer firms, etc. All of the members of committees are experts in relevant topics, a fact that implies that committees do not generally have non-expert members who would otherwise be thought of as having a political, social or economic interest in the work of the committee. Some, but by no means all, NRC committee members are elected members of the Academies.

NRC committees do not generally conduct new or original research as a part of the study process. Instead, they compile, assess, analyze, and judge the adequacy of what is known about the topic based on existing published or other literature as well as on the special knowledge and judgment of the committee members. NRC professional staff members also often contribute their expertise to formulation of a committee's findings. Committees routinely sponsor conferences and workshops to which other experts are asked to contribute data, perspectives and ideas on complex topics. If a committee determines that the base of existing knowledge is insufficient for it to come to well-founded findings, conclusions or recommendations, it may

[6] The total annual budget of the Academy complex is on the order of several hundred million dollars annually, of which more than two hundred million comes from the Federal government.

[7] Committee members are required to disclose to each other and to NRC staff any potential conflicts of interest they may have that might influence their views and work as members. Having such an interest does not disqualify a person from committee membership. To the contrary, often relevant expertise is possessed only by persons who have such conflicts, which must be carefully disclosed and managed.

recommend to the sponsoring agency or other agencies or bodies that additional research on particular topics should be supported and conducted in academia, government laboratories or elsewhere.

NRC committees are responsible for preparing a written report and recommendations, often with significant help from NRC staff. Draft reports are subjected to extensive peer review by other experts who were not involved with the study, and committee responses to those reviews are carefully monitored by yet other experts, staff, and senior Academy members to ensure that reviewers' comments on drafts are fully addressed in final reports. Generally, committees seek to reach agreement on a consensus report of their work. On occasion, however, consensus among the members is not reached, and minority views are then included in the report along with the consensus views of the majority.

The publication and submission of the report of the committee to the sponsor are important milestones in the NRC's work. Sometimes the process ends there. More commonly, however, the committee chair, senior staff assigned to the committee and other committee members seek to engage actively with the study sponsor through informal briefings, workshops, formal public presentations and the like. For high-level policy-related studies, the committee chair person may be asked to testify before one or more committees of the U.S. Congress regarding the study and its findings and recommendations. Committee leadership may write editorials and other articles for publication in journals, magazines or social media about the study, or may give speeches about it. The National Academy Press, which publishes the study reports, actively markets and disseminates those reports to the public both on-line and in hard copy.[8] Electronic copies are now available for most new reports as downloadable PDF files without charge, while hard copies are available at reasonable prices from the Press.

Impacts and Consequences of Academy Studies and Reports

As with any expert study or report, it is not straightforward to ascertain exactly what impacts or consequences an Academy study and report may have on an agency's decisions and actions, on congressional actions, or on activities of the broader public in general. Many factors influence

[8] www.nap.edu

political, scientific and technical action in the American democracy. The media, national leaders, commentators (including bloggers and those who use social media to influence others), wealthy interests, political factions, and even the weather or the actions of terrorists or natural disasters influence the course of human events. What role any particular study might play in the outcomes is often not discernable among the plethora of other influences.

Beyond that general point about the challenges of attribution of cause and effect to studies, agencies have diverse motivations for requesting Academy studies. In some cases, the requesting body may be genuinely perplexed about what to do and hopes, therefore, that an Academy study will identify the best path forward. In other cases, an agency may wish to avoid or delay acting and may request a study as a high-minded way to postpone action until the study is complete. In yet other cases, an agency may face competing demands for actions along different lines, and a study by the Academy may be a useful tool for finding and supporting the "best" options. In yet other areas in which scientific advance is very rapid, agencies may tap the Academies for studies in order to access and stay abreast of the very latest thinking in a field. Yet another motivation for a study may to raise the public and political profile of a problem or a new scientific opportunity in hopes of building support for action on it.

It should be apparent that each of the above motivations might generate a different set of expectations about what a study might do, what it might find, what it might recommend, and how it might be used. Likewise, the impacts of a study might vary widely and the scope of its consequences might range from modest to world-altering.

Thus, the impacts and consequences of an Academy study or report, even if they can be identified, can only be assessed in light of the goals for the study that motivated it in the first instance. Most certainly, the overall impact of the work of the Academies is thought by the collective polity to be worth quite a lot—the continual expenditure of hundreds of millions of dollars annually and the continual participation of thousands of uncompensated experts annually both suggest that the work is thought to be well worth doing. The science journalist, Philip Boffey, once characterized the Academies as the "Brain Bank of America."[9] Boffey's account

[9] Philip M. Boffey, The Brain Bank of America: An Inquiry into the Politics of Science, McGraw-Hill, 1975.

was not altogether favorable to the Academies but the hubris implied by his book's title suggests the importance of the Academies to the nation.

As to the impacts and consequences of individual studies, on occasion it is possible to see a rather direct connection between an Academy report and an agency's action. This might happen, for example, if the issue at hand is a relatively well-defined choice among technical alternatives for solving a problem and the Academy recommends one alternative over the others. A more far-reaching illustration is when the Academy made a number of recommendations about how to improve the competitiveness of the Unites States, which resulted in the well-known "Gathering Storm" report.[10] Observers note that that report was highly instrumental in guiding Congress to pass the 2007 America COMPETES Act. Even in that case, however, many other forces and interests played roles in encouraging Congress to take that action (and in encouraging President George W. Bush to propose the Act to Congress in the first place.)

An illustration of a different sort of impact comes from a fairly obscure NRC report for NSF in 2005 on improving measurement of R&D expenditures in the United States.[11] After the report was released, the committee chair and the NRC staff director for the committee briefed the President's Science and Technology Advisor, John Marburger, on the report. A direct outcome of that briefing was the decision by Marburger to direct the NSF to establish what became known as the Science of Science and Innovation Policy program at NSF, a program that has contributed greatly to developing new tools for R&D program evaluation and assessment. In this case, the program was not a recommendation of the committee's report; instead, the discussion of the report stimulated Marburger to ask NSF to act.

---

[10] Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future, Committee on Prospering in the Global Economy of the 21st Century, An Agenda for American Science and Technology, Committee on Science, Engineering, and Public Policy, National Academy of Sciences, National Academy of Engineering, and Institute of Medicine of The National Academies, the National Academies Press, Washington, D.C., 2007. Can be downloaded at: http://www.nap.edu/catalog/11463/rising-above-the-gathering-storm-energizing-and-employing-america-for

[11] Measuring Research and Development Expenditures in the U.S. Economy, Panel on Research and Development Statistics at the National Science Foundation, Lawrence D. Brown, Thomas J. Plewes, and Marisa A. Gerstein, Editors, Committee on National Statistics, Division of Behavioral and Social Sciences and Education, National Research Council of the National Academies, the National Academies Press, Washington, D.C., 2004. Can be downloaded at: http://www.nap.edu/catalog/11111/measuring-research-and-development-expenditures-in-the-us-economy

There are two important limitations on what the Academies are willing to discuss and incorporate in their studies and reports. The first is that NRC reports are generally prohibited by Academy culture and practice from advocating government reorganization or the creation of new government agencies. Second, NRC reports do not generally make specific recommendations for increases in government spending on R&D or other S&T activities. It is not that government organization and government budgets are not important elements in public policy of nearly any sort. It is, rather, that these recommendations are so easily arrived at by specialized committees, and, conversely, so easily dismissed by experienced political operatives that the Academy has realized it has little to gain and much to lose in terms of credibility by making recommendations in these two areas. To be sure, reports may address the pros and cons of options for government organization if such changes are a part of the national dialogue on the issue at hand. And, it is often quite clear that a report that identifies new R&D opportunities could be interpreted to mean that new investments are warranted to take advantage of them. Nonetheless, the Academies try to avoid making recommendations in these two areas whenever they can.

The Broader Context of the Work of the National Academies

The United States is blessed with a plethora of organizations and institutions that are engaged in policy studies, policy analysis, and issue advocacy in nearly every area of public concern. The field of science and technology policy is no exception. Some years ago, TPI wrote about the origins of public policy initiatives in the U.S. system, and noted that there are many pathways through which ideas are injected into the policy process and through which influencers act to get Congress and the agencies to act in one way or another.[12]

Important contributors to formulation of science and technology policy initiatives in the United States include the scientific and technical associations, such as the American Association for the Advancement of Science, the Institution of Electrical and Electronics Engineers, the American Physical Society, and the Federation of American Societies of Experimental Biology. Industry groups such as the Semiconductor Industries Association, the Aerospace Industries Association,

[12] The Decision-Making Process in U.S. Science and Technology Policy, Prepared for the Japan Science and Technology Agency, Preliminary Report, David W. Cheney, Patrick Windham, Tomoe Kiyosada, Christopher T. Hill, and George R. Heaton, Jr, Technology Policy International, November 2003. Can be downloaded at: http://technopoli.net/JST%20Report.pdf

and the National Association of Manufacturers do studies and intervene in the policy process. Non-profit think tanks like the Brookings Institution, the Center for American Progress, the American Enterprise Institute, and the Woodrow Wilson International Center for Scholars play roles. Federally-funded think tanks like the Science and Technology Policy Institute at the Institute for Defense Analysis and the RAND Corporation are important contributors to the national dialogue. The White House Office of Science and Technology Policy and various agency policy "shops" are also important, as is Congress' own Congressional Research Service, Government Accountability Office, and Congressional Budget Office. All of these and many more, including lobbyists for individual firms, universities, states and other entities, weigh in on science and technology policy matters.

In this broader context of science and technology policy analysis, advice and advocacy, the National Academies have something of a privileged status. That is, the Academies tend to be viewed as the epitome of well-informed, unbiased, objective and durable information and advice. The facts that the Academies represent the most successful scientists, engineers and medical researchers in the country and that they use rigorous processes for project management and report review contributes heavily to their credibility. The fact that they have been in existence in one form or another since 1863 also matters, as does the fact that they are headquartered in an grand old Beaux Arts marble building on the Mall in Washington, DC, directly across C Street from the Department of State and across 21st Street from the Federal Reserve Board as well as just a few blocks from the White House.

Part II -- Examples of the Roles of the National Academies in Influencing Science and Technology Initiatives

This part of the report presents some examples of how the Academy influences scientific and technical initiatives. The studies are discussed in five categories:

1. Studies of emerging opportunities and needs in specific fields
2. Studies of how problems of society might be addressed by scientific and technical initiatives

3. Reviews of federal science and technology programs
4. Studies of the Federal process for setting scientific and technical priorities
5. Other modes of exerting influence on scientific and technical initiatives.

The first three categories focus on studies that would likely be of significant interest to NEDO from a substantive perspective as well as a policy process perspective.

Studies of Emerging Opportunities and Needs in Specific Fields

A fairly large class of Academy studies is devoted to examining new and emerging opportunities in specific fields or disciplines of science, engineering or medicine. These studies are usually requested by the agencies that are responsible for supporting R&D or other activities in those fields or, sometimes, by more than one agency acting as joint requesters. Not infrequently, such studies are done every few years as needs and opportunities in fields change.

In some sense these studies are "supply-driven;" that is, they are driven by the scientific and technical communities, as represented by their sponsoring agencies, who believe that the work they are doing will "supply" new findings and new understandings that will be valued by society.

The following are some examples of supply-driven studies of opportunities in specific fields.

Study #1 "CERAMIC FIBERS AND COATINGS: ADVANCED MATERIALS FOR THE TWENTY-FIRST CENTURY," 1998.[13]

According to the report of this study, "The U.S. Department of Defense and the National Aeronautics and Space Administration requested that the National Research Council (NRC) conduct a study to recommend future research and development for advanced ceramic fibers and fiber coatings for high-temperature ceramic matrix composites (CMCs)." This highly technical study was conducted by a committee that included experts from industry and universities. It made a number of recommendations for focusing R&D efforts. Within the scope of its remit, the

[13] Ceramic Fibers and Coatings: Advanced Materials for the Twenty-First Century, Committee on Advanced Fibers for High-Temperature Ceramic Composites, National Materials Advisory Board, Commission on Engineering and Technical Systems, National Research Council, Publication NMAB-494, National Academy Press, Washington, D.C., 1998. Can be downloaded at: www.nap.edu/catalog/6042/ceramic-fibers-and-coatings-advanced-materials-for-the-twenty-first

committee offered explicit priorities among its five major recommendations. While the report is silent on the questions of who should do the R&D and who should pay for it, it is fair to assume that everyone involved assumed that the sponsors of the study—DOD and NASA—were prepared to follow through and perform or fund the recommended research.

Study #2 "A RESEARCH STRATEGY FOR ENVIRONMENTAL, HEALTH, AND SAFETY ASPECTS OF ENGINEERED NANOMATERIALS," 2012.[14]

This study was requested by the U.S. Environmental Protection Agency to "…to create a conceptual framework for EHS-related research, to develop a research plan with short-term and long-term research priorities, and to estimate resources needed to implement the research plan." This is a complex study involving multiple scientific, health and environmental disciplines that was conducted by a committee of experts from academia, industry, and public interest organizations. The committee proposed a new national strategy for R&D on topics of concern to it and made a number of specific recommendations of high priority research themes. In an unusual step for an Academy committee, it made recommendations for R&D funding levels over the next five years. It also called for establishment of a high level interagency coordinating body with both program and budgetary authority to guide R&D on environmental, health and safety aspects of engineering nanomaterials, which the committee envisioned as having greater authority over agencies than the existing NNI (National Nanotechnology Initiative.) This study illustrates that the categories of "supply-driven" and "demand-driven" Academy studies are not sharply delineated. Study #2 focuses on R&D opportunities and, in that sense, is supply-driven, but the general kind of R&D it discusses is clearly intended to address problems that have been recognized beyond the technical community and is, in that sense, demand-driven as well. The study also illustrates the strictures against organizational and budgetary recommendations are not always followed.

---

[14] A Research Strategy for Environmental, Health, and Safety Aspects of Engineered Nanomaterials, Committee to Develop a Research Strategy for Environmental, Health, and Safety Aspects of Engineered Nanomaterials, Board on Environmental Studies and Toxicology, Board on Chemical Sciences and Technology, Division on Earth and Life Studies, National Materials and Manufacturing Board, Division on Engineering and Physical Sciences, National Research Council of the National Academies, the National Academies Press, Washington, D.C., 2012. Can be downloaded at: http://www.nap.edu/catalog/13347/a-research-strategy-for-environmental-health-and-safety-aspects-of-engineered-nanomaterials

Study #3 "RESEARCH PROGRESS ON ENVIRONMENTAL, HEALTH, AND SAFETY ASPECTS OF ENGINEERED NANOMATERIALS," 2013[15]

In a somewhat unusual procedure for the Academies, in the year immediately after Study #2 was published, the same committee under the same sponsorship conducted a second study intended to assess progress in implementing the recommendations of the first study. Even though only one year had passed, the committee and its sponsor (the EPA) believed that the field of nanotechnology is moving so quickly and new knowledge about environmental, health and safety aspects of such materials is developing so rapidly, that a follow-on assessment would be valuable. This study is an example of using the Academies study process to help ensure that a previous study's recommendations are implemented.

Studies of How Societal Problems Might be Addressed by Scientific and Technological Initiatives

Another large category of Academy studies is motivated by a desire on the part of one or more agencies to determine whether and how science and technology might contribute toward resolving a problem or issue faced by society. Often, of course, there is an *a priori* understanding that the problem or issue of concern either derives from some socio-technical system or is likely to be amenable to a "technological fix" solution.

These kinds of studies are in a sense "demand-driven;" that is, the need for the study and for the guidance expected from it is demanded by parts or all of society, as represented by the agency or agencies that request the study, because they believe it will help address a problem that they have responsibility to take care on behalf of society. Because the sorts of problems that are brought to the Academies for advice are often complex and multidimensional, it is rarely the case that a scientific or technical initiative alone will be sufficient to resolve the issue. As a result,

---

[15] Research Progress on Environmental, Health, and Safety Aspects of Engineered, Nanomaterials, Committee to Develop a Research Strategy for Environmental, Health, and Safety Aspects of Engineered Nanomaterials, Board on Environmental Studies and Toxicology, Board on Chemical Sciences and Technology, National Materials and Manufacturing Board, Division on Earth and Life Studies, Division on Engineering and Physical Sciences, National Research Council of the National Academies, the National Academies Press, Washington, D.C., 2013. Can be downloaded at: http://www.nap.edu/catalog/18475/research-progress-on-environmental-health-and-safety-aspects-of-engineered-nanomaterials

Academy reports in response to such requests nearly always range well beyond the narrow scientific or technical considerations that might be implemented through, for example, a program of scientific or technical initiatives or R&D. Nonetheless, significant Federal S&T initiatives have resulted from Academy studies of important problems of society. The COMPETES Act, mentioned earlier, is one significant example.

The following are some examples of demand-driven studies of how societal problems might be addressed by scientific or technological initiatives.

Study #4 "INDUCED SEISMICITY POTENTIAL IN ENERGY TECHNOLOGIES," 2013[16]

The origin and purpose of the study is reported in the summary of the study's report, as follows: "The study arose through a request by Senator Bingaman of New Mexico to Department of Energy (DOE) Secretary Stephen Chu. The DOE was asked to engage the National Research Council to examine the scale, scope, and consequences of seismicity induced during the injection of fluids related to energy production; to identify gaps in knowledge and research needed to advance the understanding of induced seismicity; to identify gaps in induced seismic hazard assessment methodologies and the research needed to close those gaps; and to assess options for interim steps toward best practices with regard to energy development and induced seismicity potential."

This study is an excellent example of a "demand-drive" Academy study. It begins by assessing the potential seismic problems that might be associated with energy production involving injecting fluids into the grounds, using technologies such as enhanced oil recovery, fracking, and geothermal energy recovery. It analyzes historical data, describes the technologies and potential problems in depth, assesses the state of knowledge about such problems, and makes recommendations for policy action in a number of areas. For the purpose of this TPI report, the

[16] Induced Seismicity Potential in Energy Technologies, Committee on Induced Seismicity Potential in Energy Technologies, Committee on Earth Resources, Committee on Geological and Geotechnical Engineering, Committee on Seismology and Geodynamics, Board on Earth Sciences and Resources, Division on Earth and Life Studies, National Research Council of the National Academies, the National Academies Press, Washington, D.C., 2013. Can be downloaded at: http://www.nap.edu/catalog/13355/induced-seismicity-potential-in-energy-technologies

interesting aspect of the report on "induced seismicity" is that it includes a number of recommendations which, taken together, amount to a call for a new federal research and technology initiative designed to improve the data base for decision making through research and for developing new technologies to address seismic problems. Thus, a report that is motivated by recognition of a potential problem for society concludes by recommending a research and technology development agenda and initiative.

Study #5 "MATERIALS NEEDS AND R&D STRATEGY FOR FUTURE MILITARY AEROSPACE PROPULSION SYSTEMS," 2011[17]

The United States Department of Defense (DOD) asked the Academies to:

- "Examine whether current and planned U.S. research and development efforts in materials for aerospace propulsion are sufficient (a) to meet U.S. military needs and (b) to keep the U.S. on the leading edge of propulsion technology
- Consider mechanisms for the timely insertion of materials in propulsion systems and, if necessary, how these mechanisms might be improved,
- Consider mechanisms in place that retain intellectual property (IP) securely and how IP might be secured in future R&D programs, [and]
- Describe the general elements of an R&D strategy to develop materials for future military aerospace propulsion systems."

This study is an example of how the Academies can bring to bear diverse bodies of technical knowledge to help a government department address a pressing national concern—that the promise of advanced propulsion systems can be assured of the availability of advanced materials that can withstand the extreme conditions typical of such systems.

---

[17] Materials Needs and R&D Strategy for Future Military Aerospace Propulsion Systems, Committee on Materials Needs and R&D Strategy for Future Military Aerospace Propulsion Systems, National Materials and Manufacturing Board, Division on Engineering and Physical Sciences, National Research Council of the National Academies, the National Academies Press,Washington, D.C. 2011. Can be downloaded at: http://www.nap.edu/catalog/13144/materials-needs-and-research-and-development-strategy-for-future-military-aerospace-propulsion-systems

The study committee made a number of recommendations for action, as detailed in its report. Most important for this TPI study is that the study made the following recommendation for what amounts to a strategic initiative on R&D for advanced propulsion materials.

"The Air Force Research Laboratory's Materials and Manufacturing Directorate and Propulsion and Power Directorate need to develop a strategy to maintain or regain U.S. preeminence in propulsion materials. The strategy should include the regular review and updating of the directorates' propulsion materials plan, with an emphasis on the consequences of unfunded items, the changing external environment, and maintaining a balance for the near-, mid-, and far-term activities in response to the Focused Long Term Challenges and funding commitment."

This recommendation goes well beyond outlining an R&D agenda; it also outlines the need for a sustained process of management and oversight of technology-related research and implementation. While the focus of the report is on the sponsoring DOD agency, the Federal investment in materials R&D is carried out by several other agencies as well, and this DOD initiative can be expected to affect their R&D programs as well.

Reviews of Federal Science and Technology Programs

Agencies and Congress also sometimes ask the Academies to review the scientific and technical accomplishments of ongoing federal programs that have resulted from technology initiatives and to recommend possible improvements in them. The following are examples of such studies and their impact.

Study #6 "TRIENNIAL REVIEW OF THE NATIONAL NANOTECHNOLOGY INITIATIVE," 2013[18]

Section 5 of the 21st Century Nanotechnology Research and Development Act of 2003 (Public Law 108-153) requires the Director of the federal National Nanotechnology Coordination Office to contract every three years with the National Research Council for technical reviews of the National Nanotechnology Initiative. The law requires, among other things, that the NRC evaluate "the technical accomplishments of the Program, including a review of whether the Program has achieved the goals" and make "recommendations on policy, program, and budget changes with respect to nanotechnology research and development activities." The 2013 NRC report is the most recent of these reviews. As the report says, "The overall objective of the review is to make recommendations … that will improve the NNI's value for basic and applied research and for development of applications that will provide economic, societal, and national security benefits to the United States."

Study #7 "AN ASSESSMENT OF THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY CENTER FOR NEUTRON RESEARCH: FISCAL YEAR 2013," 2013[19]

This report's introduction summarizes both the purpose of this study and the long relationship between the NRC and NIST and is an example of how the NRC helps federal agencies assess and improve their scientific and technical programs.

At the request of the National Institute of Standards and Technology (NIST), annually since 1959, the National Research Council (NRC) has assembled panels of experts from academia, industry, medicine, and other scientific and engineering environments to assess the quality and

[18] Triennial Review of the National Nanotechnology Initiative, Committee on Triennial Review of the National Nanotechnology Initiative: Phase II, National Materials and Manufacturing Board, Division on Engineering and Physical Sciences, National Research Council, National Academies Press, Washington, D.C., 2013. Can be downloaded at: http://www.nap.edu/catalog/18271/triennial-review-of-the-national-nanotechnology-initiative

[19] An Assessment of the National Institute of Standards and Technology Center for Neutron Research: Fiscal Year 2013, Panel on Neutron Research, Laboratory Assessments Board, Division of Engineering and Physical Sciences, National Research Council, National Academies Press, Washington, D.C., 2013. Can be downloaded at: http://www.nap.edu/catalog/18559/an-assessment-of-the-national-institute-of-standards-and-technology-center-for-neutron-research

effectiveness of NIST measurements and standards laboratories, of which there are now six, including two user facilities, as well as the adequacy of the laboratories' resources. In 2013, NIST requested that the NRC form a panel to assess the NIST Center for Neutron Research (NCNR). This report summarizes the findings of the Panel on Neutron Research.

Studies of the Federal Process for Setting Scientific and Technical Priorities

The fourth category of Academy studies addresses the "meta-problem" of how to set priorities among all of the possible research and technology development programs and projects that might be of interest to the government. Such priorities are, of course, intimately tied to the allocation of funding among the myriad opportunities to advance knowledge and to use knowledge to solve important problems.

This kind of study is not common for the Academies, but such studies typically garner a great deal of attention in both the scientific and political worlds. We examine one such study here. While it was done some time ago, it is indicative of the approach to conducting such studies at the Academy.

Study #8 "ALLOCATING FEDERAL FUNDS FOR SCIENCE AND TECHNOLOGY," 1996.[20]

The genesis of this report was a request from the Senate Appropriations Committee that the Academies address "the criteria that should be used in judging the appropriate allocation of funds to research and development activities; to examine the appropriate balance among different types of institutions that conduct such research; and to look at the means of assuring continued objectivity in the allocation process." It is significant that this request came from the Appropriations Committee, because it is this committee of Congress that is tasked with balancing all of the competing priorities within the budget of the United States Government, both scientific and otherwise.

[20] Allocating Federal Funds for Science and Technology, Committee on Criteria for Federal Support of Research and Development, National Academy of Sciences, National Academy of Engineering, Institute of Medicine, National Research Council, National Academy Press, Washington D.C. 1995. Can be downloaded at: http://www.nap.edu/catalog/5040/allocating-federal-funds-for-science-and-technology

The study committee was made up of very high level scientists, engineers, administrators and former political leaders; all of whom were experienced in making difficult decisions among competing priorities. It was chaired by a then-recently retired president of the National Academy of Sciences, which is an indication of the importance that the Academies attached to this study.

The committee made thirteen sweeping recommendations for reform of the processes through which R&D and S&T budgets are prepared and considered at the level of individual government departments and agencies, at the level of the Executive Branch of government, and at the level of the Congress. The recommended actions amounted to a very broad initiative for reforming how R&D and other S&T activities are funded and supported in the United States. It is fair to say that most of the committee's recommendations were not implemented when the report was released and have not been implemented since.

Other Modes of Exerting Influence on Scientific and Technical Initiatives

The immediately preceding sections of this report have provided examples of how studies by the Academies seek to influence scientific and technical initiatives of the Federal government. We emphasized the work of the study committees as reflected in their reports. Those reports are provided to the sponsor, of course, and, in the vast majority of cases are also made available to the public, both on-line and in print versions.

In addition to its formal studies and reports, the Academies exert their influence in many other ways. Among these are the following:

- The Academies organize, host, and issue reports from many expert workshops on topics of interest to both the scientific and technical communities and the general public. The reports of workshops consist largely of papers prepared for the workshops by leading experts and are not considered reports of the Academies in the same sense as a report of a study conducted by a committee of the Academy.
- The leadership of the Academies, including both the elected leaders and senior NRC staff members, are active participants in myriad public and private discussions of science and

technology policy issues and priorities in government agencies, Congressional committees, think tanks, consulting organizations, foreign embassies, professional societies, and so on. They consult and advise policymakers and their staffs at every level, from the most junior project officer in an R&D program to Cabinet officials and White House staff members.

- Members of the Academies are frequently asked for their opinions and judgments on science and technology policy and planning issues, sometimes as formal participants in Congressional hearings or agency proceedings; at other times on a highly informal and private basis. The mere fact that an individual has been elected to one of the Academies lends a certain stature and credibility to whatever advice he or she might give.
- The Academies host conferences, stage speeches by leading political and industrial figures, host visiting delegations of leaders from other countries, and serve as the convening place for student contests and other activities in the support of science and technology.
- The National Academy of Engineering awards the Draper Prize annually to an individual who has made an outstanding contribution to technology development that has affected society in a major way.
- The Academies publish magazines and journals of opinion, as well as scientific journals.
- The Academies have taken the lead in convening leaders of counterpart organizations in other countries, or in encouraging the formation of academies of science and engineering in other countries to facilitate dialogue at international level.
- And many other activities too numerous to catalogue here.

Concluding Observations

The National Academies conduct a large number of science and technology policy studies each year; most of them at the request of Federal government agencies or, indirectly, at the request of the United States Congress. These studies engage the efforts of more than ten thousand volunteer experts each year including many of the several thousand members of the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. Combined with the work of more than one thousand employees of the National Research Council, the

National Academies together constitute the largest science and technology policy-oriented think tank in the world.

Owing to the nature of their Congressional charter, to the elite nature of their elected memberships, and to the quality of their study process and products, the National Academies have a privileged position among all non-governmental organizations that contribute to the formulation and analysis of science and technology policies in the United States, including the formulation and evaluation of major science and technology initiatives of the Federal government.

In keeping with most aspects of policy making in the United States, it can be difficult to identify, let alone measure, the contributions of the National Academies in general and even more difficult in specific cases. Yet, the fact that the Federal departments and agencies, as well as the Congress, return again and again to the National Academies for analysis and advice strongly suggests that their work is highly valued by policymakers and by those who are tasked to implement the policies they make.

In this report, we have argued that the National Academies contribute to the formulation and updating of science and technology policy initiatives in at least five ways:

- Studies of emerging opportunities and needs in specific fields
- Studies of how problems of society might be addressed by scientific and technical initiatives
- Reviews of Federal science and technology programs
- Studies of the Federal process for setting scientific and technical priorities
- Other modes of exerting influence on scientific and technical initiatives.

We have provided a general overview of how the National Academies contribute and have illustrated the nature of its contributions by reference to several important reports resulting from its studies.

The National Academies play an essential role in the American public policy making system by marshalling the very best talent of the country to reach consensus on what is known and not

known about the scientific and technical aspects of important national problems and by recommending actions to apply known science and technology to those problems or to develop new knowledge that can help policymakers decide what to do and how to do it. The National Academies are a major national resource that serves the United States well.